Articles

Short-Term Response of a Coastal Wetland Fish Assemblage to Tidal Regime Restoration in Oregon

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Abstract

Bandon Marsh National Wildlife Refuge, Oregon, completed construction of a large-scale tidal marsh restoration project on the Ni-les'tun Unit within the Coquille River estuary in 2011. To understand the initial effects of restoration construction and establish a baseline for long-term monitoring, we documented the assemblage of fish species 3 y before and 2 y after restoration construction. The overall fish assemblage in the Ni-les'tun Unit was substantially different after restoration construction, with an increased abundance, frequency, and richness of estuarine and diadromous fish species. Threespine Stickleback *Gasterosteus aculeatus* and species of Sculpin (family Cottidae) dominated the Ni-les'tun Unit and control area in both relative abundance and capture frequency throughout this study. Among salmonids, Coastal Cutthroat Trout *Oncorhynchus clarkii* and Coho Salmon *Oncorhynchus kisutch* had the highest frequency of occurrence and relative abundance both before and after restoration construction. Fish occupied newly constructed channels within 2 y. Species found in new channels included freshwater species (e.g., juvenile salmonids), introduced species (e.g., Mosquitofish *Gambusia affinis*), and estuarine species (e.g., Sculpin, Threespine Stickleback, and Shiner Perch *Cymatogaster aggregata*). Changes were likely due to improved access and changing habitat created by the reintroduced tidal regime. We recommend long-term monitoring to assess the trajectory of the biological response to the restoration over time.

Keywords: tidal wetland; restoration; fish assemblage; short-term response; monitoring

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Introduction

Natural tidal wetlands are some of the most highly productive habitats in the world and are characterized by an abundance of food and energy (Tiner 1984; Good 2000; Zedler and Callaway 2001; Sharitz et al. 2014). Their biological functions support biodiversity, energy flow, and nutrient cycling (Levin et al. 2001; Zedler and Callaway 2001). When intact, these ecosystems can control coastal erosion, filter nutrients and sediments from water, and sequester carbon dioxide from the atmosphere (Crooks et al. 2014). For freshwater, marine, and estuarine fish, they act as nurseries (Brockmeyer et al. 1996), offer spawning habitat (Levin et al. 2001), and provide hydrologic connectivity (Roegner et al. 2010; Davis et al. 2012). These functions may be disrupted when tidal wetlands are altered, and the result can be significant ecological changes (Bunn and Arthington 2002) and impaired productivity. Impacts from reduced habitat quality and extent suggest a need to enhance and preserve existing wetlands (Goodwin et al. 2001).

Wetland alteration and drainage in the United States began with Euro-colonization in the early 1600s (Dahl and Allord 1994). Since then, humans have converted over half of wetlands in the United States to other uses (Tiner 1984; Dahl and Allord 1994; Dahl 2011). Fisheries biologists have identified the loss of tidal wetlands, primarily through dike construction and draining, as a major factor contributing to the decline of fish populations and overall productivity of estuaries (Simenstad and Thom 1996; Myers et al. 1998; Bottom et al. 2005b). Presence of hydrologic barriers and flood control structures reduce or eliminate the opportunity for freshwater and estuarine fish to access these habitats (Roegner et al. 2010). Lack of hydrologic connectivity deprives fish of food resources, nursery habitat, and refuge from competition and predation (Madon 2008) that would have otherwise been available.

In 1986, the federal government's Emergency Wetlands Resources Act (U.S. Fish and Wildlife Service [USFWS] 1986) instituted the National Wetlands Priority Conservation Plan in an attempt to curtail wetland losses in the United States. Restoration strategies in this plan prioritize reconnection of isolated habitats to the floodplain (Roni et al. 2002, 2008). Preliminary evidence suggests that restoration of tidal wetlands may reverse habitat loss trends at local levels and can quickly improve ecological conditions for native fishes (Able et al. 2000; Williams and Faber 2001; Borja et al. 2010; Farrugia et al. 2014). After implementing these restoration projects, it is important to conduct both short- and long-term standardized research and monitoring to assess the ecosystem's response, improve our understanding of ecosystem management, and direct future wetland recoveries (Simenstad and Thom 1996; Zedler and Callaway 2001; Lindenmayer and Likens 2009; Borja et al. 2010).

In the Coquille River watershed, Oregon, greater than 97% of the tidal marshes and swamps have been lost since 1870 (i.e., 56.53 of 58.07 km^2; Benner 1992; Coquille Watershed Association 2003). In 2011, the USFWS completed construction of a large-scale tidal marsh restoration project within the Bandon Marsh National Wildlife Refuge. The goal of this project was to restore approximately 1.6 km^2 on one of Oregon's most highly altered tidal marshes (USFWS 2013), the Ni-les'tun Unit, making it one of Oregon's largest tidal marsh restoration projects to date. Restoration construction began on the Ni-les'tun Unit in 2009, which included filling drainage ditches, lowering dikes, removing tide gates, improving culverts, installing large woody debris, and excavating 8 km of tidal channels (USFWS and FHA 2009), and was completed by September 2011. Subsequent restoration included excavating additional tidal channels in 2014 (USFWS 2014). Utility and infrastructure construction included rerouting a power line underground through the project area and raising a county road above flood stage. The project's short-term goals are to restore tidal wetland function by allowing unrestricted tidal inundation and improving fish access to the Ni-les'tun Unit (USFWS and FHA 2009). Long-term goals are to improve the overall quantity and quality of tidal wetlands and estuarine conditions in the lower Coquille River watershed, facilitate natural tidal exchange, and restore function for fish and wildlife. Although there are no longer tide gates impeding access to channels and the removal of dikes allows for tidal inundation, it is important to note the site is not yet at a fully restored condition but on a trajectory toward recovery of wetland functions (Brown et al. 2016). The Salmon River, Oregon, restoration is an example of how the habitat response can continue for decades (Bottom et al. 2005a) and suggests the Ni-les'tun Unit is unlikely to reach equilibrium for many years.

Our objective was to determine an initial response of fish species post-restoration construction by documenting the short-term change in fish assemblage. We accomplished this by comparing species presence or absence, species diversity, species abundance and frequency of occurrence, and salmonid life history pre- and postrestoration. By improving access for fish to the Ni-les'tun Unit and reestablishing natural tidal regime, we expected to see increased native estuarine and diadromous fish species occupying the restored habitat.

Study Area

The Bandon Marsh National Wildlife Refuge (43°8′57″N, 124°23′25″W) is part of the Oregon Coast National Wildlife Refuge Complex and consists of 3.60 km^2 in two units: Bandon Marsh and Ni-les'tun (Figure 1). The Bandon Marsh Unit is a 1.24-km^2, nondiked tidal saltmarsh located on the south bank near the mouth of the Coquille River. Based on historic vegetation mapping, the Bandon Marsh Unit may have developed as a low sand marsh from open water within the past 150 y (Brophy 2005). This rapid accretion of new marsh may be due to increased sediment loads and hydrologic changes in the Coquille River from diking upstream pastures and road construction. The Bandon Marsh Unit differs from the Ni-les'tun Unit by its young age, immature high marsh plant community, low elevation, and lack of a perennial stream network.

The Ni-les'tun Unit is a 2.36-km^2 intertidal and freshwater marsh on the north bank of the Coquille River; it encompasses the lower reaches of three primary streams that drain to the Coquille River: Fahys Creek at Coquille River kilometer (rkm) 5 (measuring from rkm 0 the at the Pacific Ocean), No Name Creek at rkm 7, and Redd Creek at rkm 8. Most of the Ni-les'tun Unit lies within the 100-y floodplain where past landowners drained and diked the land for agricultural purposes since the early 20th century. Prior to the restoration, over 25 km of drainage ditches, 2.5 km of dikes, and three tide gates impeded connectivity of the Ni-les'tun Unit to the Coquille River (USFWS and FHA 2009). Restoration construction completed in 2011 opened all three creeks to tidal exchange and excavated 8 km of new channels. Observations made shortly after construction noted the following: water temperature and salinity approached natural regimes immediately after removal of dikes; changes in composition of the emergent plant community due to salinity; significant increase in habitat available to juvenile salmonids, which included 193 large wood structures; and sheet flow sufficient to initiate nickpoint formation and support scour/sediment deposition in channels (Brophy and van de Wetering 2012a, 2012b). Researchers expect substantial changes in channel

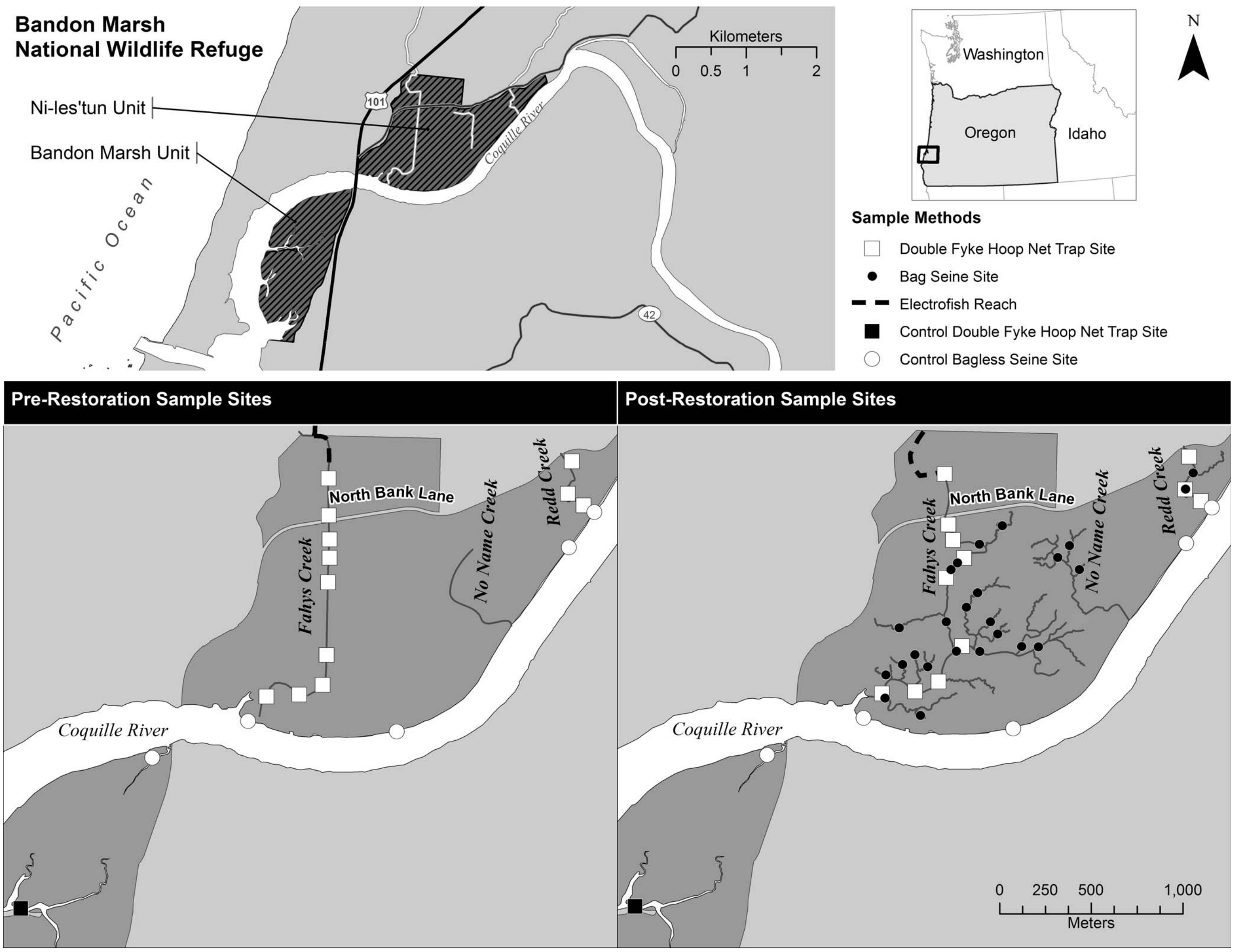

Figure 1. Bandon Marsh National Wildlife Refuge, Oregon, study area. Prerestoration tide gates were located at the outlets of Fahys (western drainage), No Name, and Redd (eastern drainage) creeks. Sample methods include double fyke hoop net trap, electrofishing, bag seine, and bagless seine. The former dike was located on the north bank of the Coquille River between Fahys Creek and No Name Creek. Sampling was conducted between November 2007 and September 2013.

morphology and sediment dynamics toward physical equilibrium to be evident for 10–15 y, likely with attendant changes in benthic macroinvertebrates (Brophy and van de Wetering 2012a). Subsequent monitoring documented substantial tidal channel development and continued progress on the site's trajectory of physical and biological attributes toward restoration (Brophy et al. 2014).

Methods

Site selection

Ni-les'tun Unit. In 2007, we selected 12 sample sites within the refuge between Fahys and Redd creeks prerestoration construction and initiated sampling the same year. We divided Fahys Creek (2,050-m reach) into six strata (F1–F6) based on habitat characteristics. The lowest three strata (F1–F3), located closest to the mouth of Fahys Creek, were channelized before restoration construction and tidally influenced after restoration construction. The upper three strata (F4–F6) were above the historic head of tide in a meandering channel constructed in 2010 with associated willow *Salix* spp. and red alder *Alnus rubra* riparian vegetation (Brophy et al. 2014). We randomly identified seven sample sites in the lower three strata (F1–F3) and two sample sites in F4; we sampled the upper two strata (F5 and F6) in their entirety. In Redd Creek, we randomly selected three sample sites in a single 400-m reach that was channelized before restoration construction and tidally influenced after restoration. All sites were at least 50 m apart and within the previously diked area (Figure 1).

Several linear segments of Fahys Creek and Redd Creek were filled during construction. Construction of the new channels of Fahys and Redd creeks included modest sinuosity and smaller feeder channels that connected adjacent wetlands (Figure 1). We shifted four sample sites on Fahys and Redd creeks laterally from the old drainage ditch to their new courses. When a cascading riffle was created to provide grade control for installation of a 4.6-m-diameter new culvert, we moved one site on Fahys Creek 10 m downstream from the F4 to the F3 strata. We identified sample sites in the newly constructed channels using a Generalized Random-Tessellation Stratified (GRTS) approach (Stevens and Olsen 2004; Figure 1). This design identified 50 randomly selected, spatially balanced sites in all channels of the Ni-les'tun Unit. We selected eight GRTS sites (e.g., numbers 1–8) each trip to provide a spatially balanced sample throughout the study. For each subsequent sample event, we sampled the last four GRTS sites from the previous trip (e.g., numbers 5–8) and the next four GRTS sites (e.g., numbers 9–12) to broadly monitor the newly constructed channels while accounting for seasonal variation within and among sites and maintaining the spatially balanced design. We eliminated sites if they were dewatered or $>$ 1 m deep at the time of sampling. We conducted sampling at least once each season pre- and post-restoration construction with a maximum of 8 wk between sample events.

Control area. We used six control sites within the Bandon Marsh Wildlife Refuge: two on the Bandon Marsh Unit and four along the Coquille River. We randomly selected two Bandon Marsh Unit sites in tidal channels within the Coquille River estuary. We arbitrarily selected four sites on the north bank of the mainstem Coquille River adjacent to the Ni-les'tun Unit to sample above and below the mouths of Redd and Fahys creeks (Figure 1). Sampling occurred on the same schedule as the Ni-les'tun Unit.

Fish sampling

Given the multiple habitats ranging in salinity and depth, we used multiple fishing gears conducive to the habitat conditions and adapted to varying hydrology patterns (i.e., tidally influenced, riparian). We used double fyke hoop net traps to passively capture fish in the tidally influenced channels through at least one tidal cycle, backpack electrofishing to actively collect fish in wadeable freshwater, and seining to actively collect fish in shallow water at the tide line. We sampled during moderate tides to prevent fish stranding (fish trapped in a fyke net with little to no water at low tide) and to minimize their stress in nets. We used double fyke hoop net traps in the lowest strata (F1–F4) on the Ni-les'tun Unit for all 15 sample events pre-restoration construction and all 12 sample events post-restoration construction. We used round fyke nets of three different diameters (0.76 m, 0.91 m, and 1.22 m) to best fit the channel size and water depth at each site. All nets were constructed with 6.35-mm knotless netting and consisted of four galvanized steel hoops, two throats, and two wings (each 1 m deep, 4 m long, with float and lead lines). We joined each set of nets at their cod ends and deployed them along the channel thalweg. We secured each wing to the adjacent channel bank by tying its float line to a fencepost driven into the substrate. Blocking the width of the channel allowed us to sample both incoming and outgoing tides and upstream and downstream fish movements. Fishing occurred overnight for $>$ 21 h. We pulled nets in the order by which they were set to allow for similar fishing effort (i.e., hours fished).

We conducted backpack electrofishing with a Smith-Root LR-24 backpack electrofisher (Smith-Root, Vancouver, WA) in the upper two strata of Fahys Creek (F5 and F6) above the head of tide. We conducted five sampling events pre-restoration construction (mean effort per event: 2,628 s) and four events post-restoration construction (mean effort per event: 1,997 s), occurring in the spring and fall. For all sample events, two dip-netters using 6.35-mm mesh nets worked with one electrofisher and moved upstream with no blocknets. We conducted electrofishing in compliance with the National Marine Fisheries Service's (NMFS) Backpack Electrofishing Guidelines (NMFS 2000) to reduce potential harm to the sampled population for all efforts. The backpack electrofisher used pulsed direct current set at a frequency of 24–30 hertz, 13–18% duty cycle, and 325–450 volts. All settings were subject to modification depending on conditions (e.g., water depth, conductivity, temperature, and flow).

Post-restoration construction, we seined 26 GRTS sites (range 1–8 times) during 12 sample events. High-water events in fall 2011, spring 2012, and winter 2012 prevented access to sites located in the lower strata. We used a 5-m-wide, 1-m-deep, 6-mm-mesh bag seine as opposed to double fyke hoop net traps to prevent stranding fish in newly constructed channels that were susceptible to dewatering at low tide. Two people pulled the seine 25 m upstream to a block net staked to the width of the channel to inhibit fish escaping the seine. They manually removed fish removed from the seine's bag when it was pulled up onto the channel bank.

We sampled one control site on the Bandon Marsh Unit with double fyke hoop net traps during 11 sample events pre-restoration construction and 11 sample events post-restoration construction. We used double fyke hoop net traps to sample another control site on the Bandon Marsh Unit during six sample events pre-restoration construction before changing to a seine to prevent fish stranding. We also seined this control site during 5 sample events pre-restoration construction and 11 sample events post-restoration construction. We seined all other control sites during 9 sample events pre-restoration construction and 11 sample events post-restoration construction. We used a larger bagless seine (15.2 m, 1.8 m deep, and 6.4-mm mesh) to sample all control sites. One person held one end of the net at shoreline while a second person fully extended the other end upstream of the anchored end. We then pulled the net out in a wide arc, swept it downstream past the anchored end, and towed it back to the bank in a half-arc seine haul (Curry et al. 2009). We pulled the float-lines to shore simultaneously while keeping the lead-line in contact with the substrate. We manually removed fish from the seine when it was next to the shore.

For all sample methods, we placed captured fish into an aerated 5-gallon bucket from which we visually identified and counted each fish. We differentiated Coastal Cutthroat Trout from *O. mykiss* and their hybrids in the field by phenotypic diagnostic characteristics from both species (Hawkins 1997). We measured the first 20 individuals of each species for fork length (mm) and included weight (g) for salmonid species. We released all fish at the capture location. We measured water temperature (°C), specific conductivity (μS/cm), and salinity (parts per thousand) at each site when we pulled the nets.

Fish assemblage analysis

Presence/absence. To document change in the fish assemblage with a similarity coefficient based on species presence or absence, we first categorized fish occurrence (i.e., freshwater, Pacific Ocean [estuarine], or both [diadromous]) according to Page et al. (2013) and identified nonindigenous fish species according to the U.S. Geological Survey (USGS 2016). We used Jaccard's coefficient (S_J) to calculate the proportion of unique species captured pre- and post-restoration construction (Urbani 1980):

$$S_J = \frac{a}{(a+b+c)},$$

where a is the number of species present pre- and post-restoration construction, b is the number of unique species pre-restoration construction, and c is the number of unique species post-restoration construction. This coefficient ranges from 0.0, for no shared species, to 1.0 to identical species composition. Values of less than 0.60 are thought by statisticians to indicate a substantial difference beyond what is expected from sampling error (Gauch 1982; Rahel 1990). We calculated Jaccard's coefficient for the Ni-les'tun Unit assemblage (all sites and sample methods pooled) pre- and post-restoration construction and for the control area assemblage (all sites and sample methods pooled) pre- and post-restoration construction.

Species diversity. We used the Simpson's index of diversity ($1 - D$) to describe the assemblage with an emphasis on abundant species:

$$1 - D = \frac{\sum n(n-1)}{N(N-1)},$$

where n is the number of individuals from one particular species and N is the total number of individuals found. The index ranges between 0 and 1, where 0 represents no diversity and approaches 1 as numbers of individuals collected are evenly distributed among the number of species present (evenness of abundance; Kwak and Peterson 2007). The index is the probability that two individuals randomly selected from a sample will belong to different species. We calculated Simpson's index of diversity for each sample event in the Ni-les'tun Unit and the control area to capture temporal variation (e.g., we sampled 11 sites with double fyke hoop net traps 15 times [events] pre-restoration construction on the Ni-les'tun Unit). To prevent bias associated with sampling sites created after restoration construction, we only compared sites sampled both pre- and post-restoration construction within the tidally influenced strata. We used a two-tail t-test ($\alpha = 0.05$) assuming equal variances to compare the mean diversity index in the Ni-les'tun Unit pre- and post-restoration construction and in the control area pre- and post-restoration construction.

Ecological classification. We ecologically classified each species encountered within the Ni-les'tun Unit or the control area (Dominant, Common, Occasional, and Rare) according to total relative abundance and percent frequency of occurrence for each sample event (González-Acosta 1998; González-Acosta et al. 2005). This method of classification is based on Olmstead-Tukey's test (Sokal and Rohlf 1969) and allows an ecological and quantitative classification of the species in each area (González-Acosta et al. 2005). The analysis results in the division of species present into four ecological categories (Dominant, Common, Occasional, and Rare) represented by quadrants of a scatter plot divided by two axes identifying the mean frequency of occurrence and mean relative abundance for a specific area. We aggregated all sites and sample methods for each sample event in each the Ni-les'tun Unit and the control area. We compared species classifications pre- and post-restoration construction to document changes in both relative abundance and frequency of occurrence.

Salmonid life history diversity and relative abundance. We compared the proportion of salmonids within different size classes in the Ni-les'tun Unit and control area pre- and post-restoration construction. Because different sampling gears have different biases and catchabilities (Hayes et al. 2012; Hubert et al. 2012), we combined fish captured by all sample gears (i.e., double fyke hoop net traps, electrofish, bag seine, and bagless seine) for each species where the sum of measured individuals was > 30. We characterized Coastal Cutthroat Trout *Oncorhynchus clarkii* as juveniles (< 100 mm fork length), large juveniles (100–199 mm), adults (200–299 mm), and sea run (> 300 mm; Giger 1972). We also characterized Chinook Salmon *O. tshawytsha*, and Coho Salmon *O. kisutch* by size class as small juvenile (< 60 mm fork length) or large juvenile (60–150 mm; Miller and Sadro 2003).

We used catch per unit of effort (CPUE) to measure the relative abundance of salmonid species collected by sampling gear. We calculated the number of fish captured per hour of soak time for each double fyke hoop net trap, hour of electrofishing, and per seine haul. We used a two-tailed t-test ($\alpha = 0.05$) to compare the CPUE of each salmonid species with each gear type for

Table 1. Estuarine, freshwater, diadromous, and nonindigenous species found at Bandon Marsh National Wildlife Refuge, Oregon, on the Ni-les'tun Unit and in the control area pre- and post-restoration construction. We conducted sampling between November 2007 and September 2013. Numbers in parentheses indicate trout fry.

			Ni-les'tun Unit		Control area	
Family	Genus species	Common name	Prerestoration	Postrestoration	Prerestoration	Postrestoration
Centrarchidae	*Lepomis macrochirus*	Bluegill[b,d]	3	3	—	—
	Micropterus dolomieu	Smallmouth Bass[b,d]	1	—	—	—
	Micropterus salmoides	Largemouth Bass[b,d]	2	—	—	1
	Pomoxis sp.	Crappie[b,d]	—	4	—	—
Clupeidae	*Alosa sapidissima*	American Shad[c,d]	—	110	1	4
Cottidae	Unknown	Sculpin spp.[a,b]	6,056	5,700	3,591	6,980
Cyprinidae	*Cyprinus carpio*	Common Carp[b,d]	1	—	—	—
Embiotocidae	*Cymatogaster aggregate*	Shiner Perch[c]	3	1,345	4,130	380
Engraulidae	*Engraulis mordax*	Northern Anchovy[a]	—	14	—	—
Gasterosteidae	*Gasterosteus aculeatus*	Threespine Stickleback[c]	5,892	9,408	4,722	2,529
Ictaluridae	*Ameiurus nebulosus*	Brown Bullhead[b,d]	11	6	—	—
Osmeridae	Unknown	Smelt sp.[c]	1	72	1	4
Petromyzontidae	*Entosphenus tridentatus*	Pacific Lamprey[c]	—	—	—	1
Pholidae	*Pholis* sp.	Gunnel[a]	82	183	67	4
Pleuronectidae	*Platichthys stellatus*	Starry Flounder[c]	—	22	27	53
Poeciliidae	*Gambusia affinis*	Western Mosquitofish[b,d]	19	9	—	—
Salmonidae	*Oncorhynchus clarki*	Coastal Cutthroat Trout[c]	681 (24)	231 (73)	—	—
	O. clarki × *O. mykiss*	Hybrid Trout[b]	56	10	—	—
	Oncorhynchus kisutch	Coho Salmon[c]	1,719	533	50	120
	Oncorhynchus mykiss	Steelhead Trout[c]	22	—	—	—
	Oncorhynchus tshawytscha	Chinook Salmon[c]	35	144	18	86
Syngnathidae	*Syngnathus leptorhynchus*	Bay Pipefish[a]	—	1	—	1

[a] Estuarine species ($n = 4$).
[b] Freshwater species ($n = 9$).
[c] Diadromous species ($n = 10$).
[d] Nonindigenous species ($n = 8$).

both before and after restoration construction in the Ni-les'tun Unit and control area.

Results

Fish sampling

In the Ni-les'tun Unit, 21 species representing 15 families were present (Table 1; Data S1, *Supplemental Material*). Pre-restoration construction, native fish species captured included Chinook Salmon, Coastal Cutthroat Trout, Coho Salmon, Gunnel *Pholis* sp., hybrid Trout *O. clarkii* × *O. mykiss*, Sculpin (family Cottidae), Smelt (family Osmeridae), Shiner Perch *Cymatogaster aggregate*, juvenile Steelhead *O. mykiss*, and Threespine Stickleback *Gasterosteus aculeatus*. Nonindigenous fish species captured were Bluegill *Lepomis macrochirus*, Brown Bullhead *Ameiurus nebulosus*, Common Carp *Cyprinus carpio*, Largemouth Bass *Micropterus salmoides*, Smallmouth Bass *Micropterus dolomieu*, and Mosquitofish *Gambusia affinis*. Post-restoration construction, we captured additional native fish species such as Bay Pipefish *Syngnathus leptorhynchus*, Northern Anchovy *Engraulis mordax*, and Starry Flounder *Platichthys stellatus*. Additional nonindigenous species captured post-restoration construction were American Shad *Alosa sapidissima* and Crappie *Pomoxis* sp. We captured 9 diadromous or estuarine fish species pre-restoration construction and 12 diadromous or estuarine fish species post-restoration construction, an increase of 33% (Table 1). In the newly excavated channels, we found Chinook Salmon, Coho Salmon, Mosquitofish, Sculpin, Threespine Stickleback, and Shiner Perch. Composition and frequency of species captured varied each sampling trip.

Twelve species representing 11 families were present in the control area. Native fish species captured in the control area pre-restoration construction included Chinook Salmon, Coho Salmon, Gunnel, Sculpin, Shiner Perch, Smelt, Starry Flounder, and Threespine Stickleback. American Shad were the only nonindigenous fish species. Additional species found post-restoration construction were a native Pacific Lamprey *Entosphenus tridentatus*, native Bay Pipefish, and a nonindigenous Largemouth Bass. We captured 9 diadromous or estuarine fish species pre-restoration construction and 11 diadromous or estuarine fish species post-restoration construction, a 22% increase (Table 1).

Fish assemblage

Presence/absence. Jaccard's coefficient for similarity showed overall species assemblage in the Ni-les'tun Unit was substantially different post-restoration construction ($S_J = 0.57$). Twelve species were present pre- and post-restoration construction, four were found pre-restoration construction only (Common Carp, Largemouth Bass, Smallmouth Bass, and Steelhead), and five were found post-restoration construction only (American Shad, Bay

Table 2. Mean and standard deviation (SD) of the Simpson's index of diversity ($1 - D$) for species captured in the Ni-les'tun Unit and control area of Bandon Marsh National Wildlife Refuge, Oregon, pre- and post-restoration construction. We conducted sampling between November 2007 and September 2013.

Sample area	Phase	No. of sample events	Mean (SD)	Minimum	Maximum
Ni-les'tun Unit	Pre-restoration	15	0.567 (0.097)	0.315	0.703
	Post-restoration	12	0.541 (0.131)	0.207	0.653
Control area	Pre-restoration	11	0.459 (0.174)	0.145	0.683
	Post-restoration	11	0.404 (0.163)	0.139	0.613

Pipefish, Crappie, Northern Anchovy, and Starry Flounder; Table 1). In the control area, Jaccard's coefficient for similarity showed overall species assemblage was not substantially different post-restoration construction ($S_J = 0.75$). Nine species were present pre- and post-restoration construction (Chinook Salmon, Coho Salmon, Gunnel, Sculpin, Shiner Perch, Smelt, Starry Flounder, Threespine Stickleback, and American Shad), zero were present pre-restoration construction only, and three were present post-restoration construction only (Pacific Lamprey, Bay Pipefish, and Largemouth Bass; Table 1).

Species diversity. There was a not a significant difference in the Simpson's index of diversity in the Ni-les'tun Unit or in the control area pre- and post-restoration construction. In the Ni-les'tun Unit, the mean (SD) Simpson's index of diversity was 0.57 (0.10) pre-restoration construction. Post-restoration construction in the Ni-les'tun Unit the mean (SD) was 0.54 (0.13; $t_{25} = 0.56$, $P = 0.56$; Table 2). In the control area, the mean (SD) Simpson's index of diversity was 0.46 (0.17) pre-restoration construction. Post-restoration construction in the control area the mean (SD) Simpson's index of diversity was 0.40 (0.16; $t_{20} = 0.75$, $P = 0.46$; Table 2).

Ecological classification. In the Ni-les'tun Unit pre-restoration construction, we captured 14,608 fish, mean (SD) relative abundance of each species was 0.059 (0.135) and mean (SD) percent frequency of occurrence was 47.45 (34.55). We classified Coho Salmon, Sculpin, and Threespine Stickleback as Dominant; Chinook Salmon, Coastal Cutthroat Trout, and hybrid Trout were Common; Bluegill, Brown Bullhead, Common Carp, Gunnel, Largemouth Bass, Mosquitofish, Shiner Perch, Smallmouth Bass, Smelt, and Steelhead were Rare. Post-restoration construction, we captured 17,868 fish, mean (SD) relative abundance of each species was 0.056 (0.139) and mean (SD) percent frequency of occurrence was 46.76 (32.61). We reclassifed Coho Salmon as Common, Shiner Perch as Occasional, and hybrid Trout as Rare. Species no longer present post-restoration construction included Common Carp, Largemouth Bass, Smallmouth Bass, and Steelhead. New species present post-restoration construction included Starry Flounder (classified Common) and American Shad, Bay Pipefish, Crappie, and Northern Anchovy (Rare; Figure 2a).

In the control area pre-restoration construction, we captured 12,607 fish, mean (SD) relative abundance of each species was 0.111 (0.156) and mean (SD) percent frequency of occurrence was 54.55 (30.90). We classified Sculpin and Threespine Stickleback as Dominant; Coho Salmon, Gunnel, and Starry Flounder were Common; Shiner Perch were Occasional; American Shad, Chinook Salmon, and Smelt were Rare. Post-restoration construction, we captured 10,163 fish, mean (SD) relative abundance of each species was 0.083 (0.194) and mean (SD) percent frequency of occurrence was 40.15 (33.90). We reclassified Chinook Salmon and Shiner Perch as Common, and Gunnel as Rare. New species present post-restoration construction included Bay Pipefish, Largemouth Bass, and Pacific Lamprey; we classified all as Rare (Figure 2b).

Salmonid life history diversity and relative abundance. The same size-classes of Coastal Cutthroat Trout, Chinook Salmon, and Coho Salmon were present pre- and post-restoration construction on the Ni-les'tun Unit. Four size-classes of Coastal Cutthroat Trout (juvenile, large juvenile, adult, and sea run), two size-classes of Coho Salmon (small juvenile and large juvenile), and two size-classes of Chinook Salmon (small juvenile and large juvenile) were present both pre- and post-restoration construction. The majority of Coastal Cutthroat Trout were in the large juvenile size class (70% pre-restoration construction, 64% post-restoration construction), and the majority of Coho Salmon were in the large juvenile size class (99% pre-restoration construction, 96% post-restoration construction). There was an increase in the proportion of sea run Coastal Cutthroat Trout (0.1 to 2%), small juvenile Coho Salmon (1 to 4%), and small juvenile Chinook Salmon (9 to 63%) post-restoration construction (Table 3). There was a decrease in the proportion of large juvenile Chinook Salmon (91 to 37%) post-restoration construction (Table 3). Two age-classes (small juvenile and large juvenile) of Coho Salmon and Chinook Salmon were present pre- and post-restoration construction in the control area. The majority of Coho Salmon were in the large juvenile size class (90% pre-restoration construction, 92% post-restoration construction); the majority of Chinook Salmon were in the large juvenile size class (89%) pre-restoration construction and in the small juvenile size class (54%) post-restoration construction. There was an increase in the proportion of small juvenile Chinook Salmon (11 to 54%) post-restoration construction (Table 3).

The CPUE of Coastal Cutthroat Trout and Coho Salmon in Ni-les'tun Unit double fyke hoop net traps was significantly lower after restoration construction ($t_{584} = 2.27$, $P = 0.02$ and $t_{584} = 2.06$, $P = 0.04$); Chinook Salmon

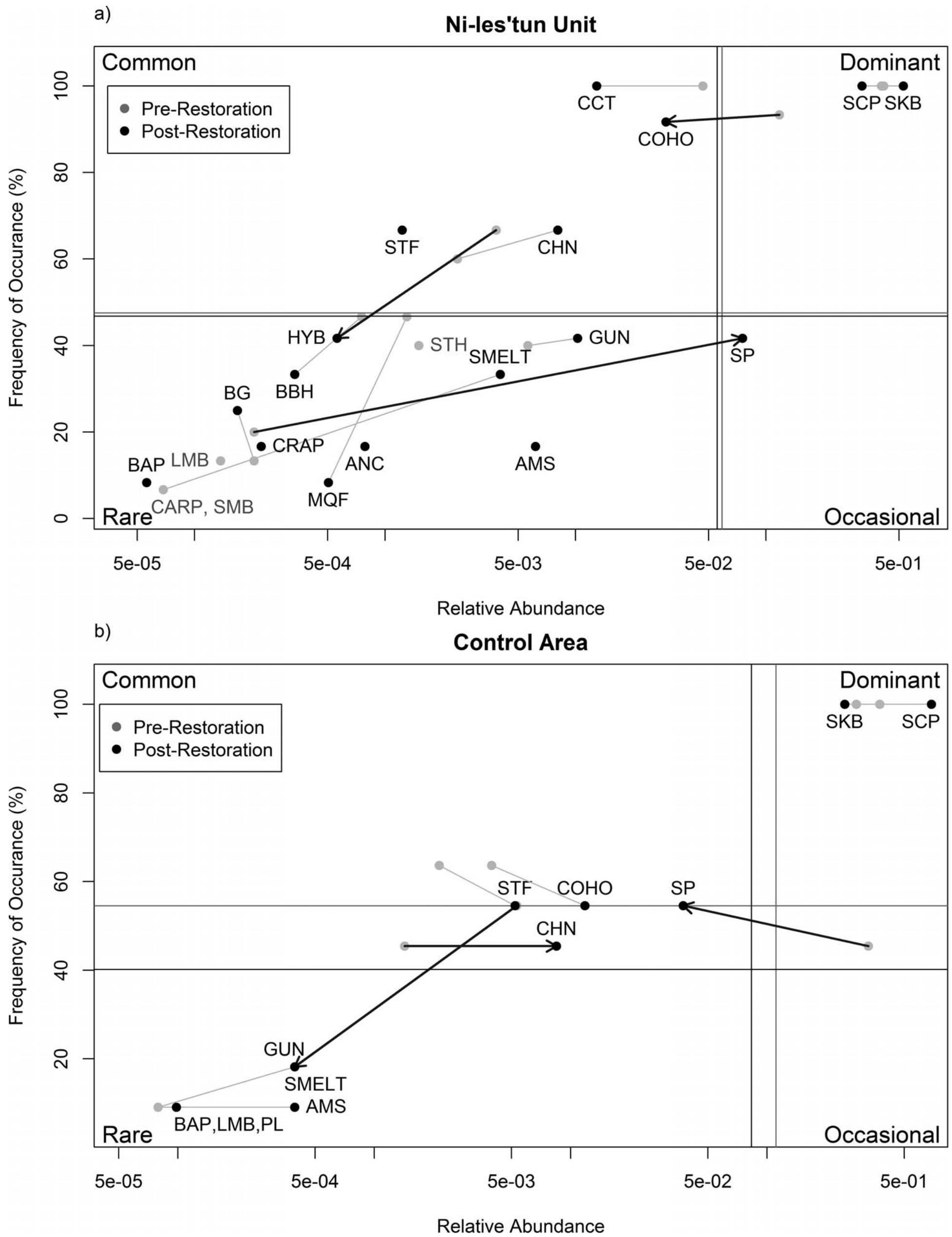

Figure 2. Relative abundance and percentage of frequency of occurrence of each species in the (**a**) Ni-les'tun Unit and (**b**) control area of Bandon Marsh National Wildlife Refuge, Oregon. Two axes (mean frequency of occurrence and mean relative abundance) delineate the four ecological classifications (Dominant, Common, Occasional, and Rare). Prerestoration values are in gray, postrestoration values are in black. Arrows indicate species reclassified after restoration construction. We conducted sampling between November 2007 and September 2013. AMS, American Shad *Alosa sapidissima*; ANC, Northern Anchovy *Engraulis mordax*; BAP, Bay Pipefish *Syngnathus leptorhynchus*; BBH, Brown Bullhead *Ameiurus nebulosus*; BG, Bluegill *Lepomis macrochirus*; CARP, Common Carp *Cyprinus carpio*; CCT, Coastal Cutthroat Trout *Oncorhynchus clarkii*; CHN, Chinook Salmon *Oncorhynchus tshawytscha*; COHO, Coho Salmon *Oncorhynchus kisutch*; CRAP, Crappie *Pomoxis* sp.; GUN, Gunnel *Pholis* sp.; HYB, hybrid Trout *Oncorhynchus clarkii* × *Oncorhynchus mykiss*; LMB, Largemouth Bass *Micropterus salmoides*; MQF, Mosquitofish *Gambusia affinis*; PL, Pacific Lamprey *Entosphenus tridentatus*; SCP, *Sculpin* spp. family Cottidae; SKB, Threespine Stickleback *Gasterosteus aculeatus*; SMB, Smallmouth Bass *Micropterus dolomieu*; SMELT, Smelt (family Osmeridae); SP, Shiner Perch *Cymatogaster aggregata*; STF, Starry Flounder *Platichthys stellatus*; STH, Steelhead Trout *Oncorhynchus mykiss*.

CPUE was significantly higher ($t_{584} = -2.38$, $P = 0.02$; Table 4). The mean CPUE of Coastal Cutthroat Trout for all double fyke hoop net trapping efforts in the Ni-les'tun Unit before restoration construction was 125.81 and 78.95 after. The mean CPUE of Coho Salmon for all double fyke hoop net trapping efforts in the Ni-les'tun Unit before restoration construction was 23.77 and 27.81 after. The mean CPUE for seining in the Ni-les'tun Unit

Table 3. Number and proportion of size classes of Coastal Cutthroat Trout *Oncorhynchus clarkii*, Coho Salmon *Oncorhynchus kisutch*, and Chinook Salmon *Oncorhynchus tshawytscha* captured at Bandon Marsh National Wildlife Refuge, Oregon, across all sample methods (electrofishing, double fyke hoop net traps, and seine) in the Ni-les'tun Unit and the control area prerestoration and post-restoration construction. We categorized Coastal Cutthroat Trout as juveniles ($<$ 100 mm fork length), large juveniles (100–199 mm), adults (200–299 mm), and sea run ($>$ 300 mm; Giger 1972). We categorized Chinook Salmon and Coho Salmon as small juvenile ($<$ 60 mm fork length) and large juvenile (60–150 mm; Miller and Sadro 2003). We conducted sampling between November 2007 and September 2013.

Sample area	Species	Size class	No. captured pre-restoration construction (proportion, %)	No. captured post-restoration construction (proportion, %)
Ni-les'tun Unit	Coastal Cutthroat Trout	Juvenile	162 (24)	77 (26)
		Large juvenile	484 (70)	192 (64)
		Adult	43 (6)	24 (8)
		Sea run	1 ($<$ 1)	7 (2)
	Coho Salmon	Small juvenile	14 (1)	16 (4)
		Large juvenile	1,003 (99)	417 (96)
	Chinook Salmon	Small juvenile	3 (9)	90 (63)
		Large juvenile	32 (91)	53 (37)
Control area	Coho Salmon	Small juvenile	5 (10)	5 (8)
		Large juvenile	44 (90)	59 (92)
	Chinook Salmon	Small juvenile	2 (11)	45 (54)
		Large juvenile	16 (89)	39 (46)

after restoration construction was 0.15 for Coho Salmon and 0.25 for Chinook Salmon. Electrofishing CPUE was not significantly different for any species. The mean electrofishing CPUE for Coastal Cutthroat Trout was 125.81 before restoration construction and 78.95 after; for Coho Salmon the mean was 23.77 before and 27.81 after. In the control area, seine CPUE of Chinook Salmon was significantly higher after restoration construction ($t_{94} = -1.99$, $P = 0.05$). CPUE was not significantly different for any other species or sample methods in the control area. The mean CPUE of Coho Salmon for double fyke hoop net trapping in the control area was 0.07 before restoration construction on the Ni-les'tun Unit and 0.23 after, Chinook Salmon mean CPUE was 0.01 before and 0.02 after. The mean CPUE for seining Coho Salmon in the control area was 0.29 before restoration construction on the Ni-les'tun Unit and 0.25 after, Chinook Salmon mean CPUE was 0.24 before restoration construction and 1.42 after.

Discussion

Within 3 y after restoration construction, the overall fish assemblage in the Ni-les'tun Unit was substantially different from before restoration construction. Although Threespine Stickleback and species of Sculpin continue to dominate in both relative abundance and capture frequency, the number of estuarine and diadromous species increased, fish moved into the newly excavated channels, and species diversity did not significantly change after restoration construction. We observed a decline in the relative abundance of Coastal Cutthroat Trout and Coho Salmon in the tidally influenced area of the Ni-les'tun Unit after construction. However, we detected a greater abundance of small juvenile Chinook

Table 4. Mean catch per unit effort (CPUE) and standard deviation (SD) for Coastal Cutthroat Trout *Oncorhynchus clarkii*, Coho Salmon *Oncorhynchus kisutch*, and Chinook Salmon *Oncorhynchus tshawytscha* captured in the Ni-les'tun Unit and control area of Bandon Marsh National Wildlife Refuge, Oregon, pre- and post-restoration construction. We determined fishing effort (CPUE) by number of fish captured per double fyke hoop net trap soaking hour, number of fish captured per hour electrofishing, and number of fish captured per seine haul. We conducted sampling between November 2007 and September 2013. Statistically significant comparisons with a two-tail *t*-test ($P < 0.05$) are indicated with an asterisk.

Sample area	Sample method	Species	Mean pre-restoration CPUE (SD)	Mean post-restoration CPUE (SD)	*t*-statistic	*P*
Ni-les'tun Unit	Electrofish	Coastal Cutthroat Trout	125.81 (77.52)	78.95 (71.17)	1.46	0.16
		Coho Salmon	23.77 (30.16)	27.81 (43.76)	−0.26	0.80
	Double fyke	Coastal Cutthroat Trout	0.03 (0.07)	0.02 (0.08)	2.27	0.02*
		Coho Salmon	0.22 (0.78)	0.11 (0.46)	2.06	0.04*
		Chinook Salmon	0.01 (0.03)	0.07 (0.50)	−2.38	0.02*
	Seine	Coho Salmon	n/a	0.15 (0.70)	n/a	n/a
		Chinook Salmon	n/a	0.25 (1.05)	n/a	n/a
Control area	Double fyke	Coho Salmon	0.07 (0.14)	0.23 (0.79)	−1.03	0.31
		Chinook Salmon	0.01 (0.04)	0.02 (0.06)	−0.31	0.76
	Seine	Coho Salmon	0.29 (1.15)	0.25 (0.70)	0.20	0.84
		Chinook Salmon	0.24 (0.89)	1.42 (3.70)	−1.99	0.05*

Salmon in both the Ni-les'tun Unit and control area; this was likely a reflection a population increase system-wide. Overall, the short-term response of fish species to the restoration actions in the Ni-les'tun Unit suggests the project is meeting its short-term goals and our monitoring reflects the initial response of fish to the early conditions created by the restoration actions. We expect to see continued changes in physical and biological attributes over time due to natural processes, which include the natural hydrology, channel network density, and fish use of tidal channels reaching a stable state (Bottom et al. 2005a). This helps to emphasize the need for future monitoring to assess whether this project meets its long-term goals.

Wetland restoration benefits estuarine fish by creating suitable habitat and increasing access to additional forage and cover (Keller and Swanson 1979; Scott et al. 1986; Shreffler et al. 1992; Miller and Simenstad 1997; Gray et al. 2002). The reintroduced natural tidal regime on the Ni-les'tun Unit allows brackish tidal flows to penetrate into the uppermost channels. These tidal flows increase water salinity and groundwater levels, and provide periods of inundation (Brophy et al. 2014). Consequently, the fluctuating postrestoration hydrology excludes some of the nonindigenous species that primarily inhabited the freshwater conditions prerestoration while supporting native species that tolerate salinity (or eliminating those that do not). The addition of large woody debris has created conditions on the Ni-les'tun Unit that are more dynamic by forming scour pools and sediment bars. Along with increased channel complexity, there were over 8 km of new tidal channels during the period of our monitoring. The removal of tide gates has allowed unrestricted access to these channels for migrating salmonids and estuarine fish.

We sampled the control area primarily by seine due to its tidal nature and lack of perennial streams. To prevent fish stranding, we changed one site on the Bandon Marsh Unit from a double fyke hoop net trap to a seine, which likely resulted in a lower abundance of shiner perch captured post-restoration construction. Additionally, the absence of a perennial stream and spawning habitat above the sample sites in the control area could explain why Coastal Cutthroat Trout were not present. The Ni-les'tun Unit differs from the Bandon Marsh Unit and Coquille River by its plant community, elevation, and connectivity to the Coquille Estuary. The lack of comparable habitat in the control area precludes a direct comparison with the entire Ni-les'tun Unit (Short et al. 2000). Therefore, we have focused our discussion of restoration effects here to sites sampled below the head of tide (i.e., the lowest three strata) within the Ni-les'tun Unit and the control area.

Fish assemblage changed substantially within 3 y after restoration construction. This was evident, for example, by an increase in estuarine and diadromous species as reflected by the change in species richness. The proximity of source populations of estuarine and diadromous fishes in the control area likely facilitated recolonization of newly available habitats (Pess et al. 2014). A diversity of life history stages is supported by the restoration of tidal habitat for fish immigrating into the Ni-les'tun Unit from the estuary while maintaining freshwater habitat for species upstream. Previous studies support our observation of rapid estuarine fish colonization on constructed and reconnected channels (Williams and Zedler 1999; Madon 2008). Madon (2008) found juvenile California Halibut *Paralichthys californicus* occupied similar restored habitat where they fed on small-sized prey that were typically less abundant in larger streams. We observed Starry Flounder, an analogous estuarine species, in the Ni-les'tun Unit after restoration construction, perhaps for the same reason.

We can attribute the lack of change in species diversity to the fact that sculpin and Threespine Stickleback remained a dominant proportion of the total catch pre- and post-restoration construction. Though there was an increase in total species, most were rare, and their equity or evenness of abundance remained low. The Giacomini Wetland Restoration at Point Reyes National Seashore, California saw similar results (Parsons and Ryan 2015) where Threespine Stickleback were consistently the most abundant species in the project area within 5 y after restoration. The large numbers of Sculpin and Threespine Stickleback, with few individuals of other species, may indicate the newly excavated habitat is more suitable for species that can withstand great changes in temperature and salinity, and occasional dewatering. We sampled the channels at low tide when the habitat was accessible. During high-water events, the channels were inundated for longer periods with cold water from outside the Ni-les'tun Unit and there may have been species present but not captured at these times. The habitat within these new channels appears to successfully attract fish that can exploit new habitats quickly (Williams and Zedler 1999). It will be valuable to understand how other species use these newly constructed channels during high tide and over time as the channels change with regular inundation.

Restoration appears to have resulted in a shift toward species associated with the tidal wetland, specifically for native estuarine species. While Sculpin, Threespine Stickleback, Coho Salmon, Chinook Salmon, and Coastal Cutthroat Trout were relatively abundant pre- and post-restoration construction, we observed an increase in the relative abundance of Shiner Perch and the arrival of species such as American Shad, Bay Pipefish, Northern Anchovy, Smelt, and Starry Flounder after restoration construction. Similarly, Able et al. (2000) found greater relative abundance of fish species in restored intertidal creeks when compared to prerestoration condition. As the Ni-les'tun Unit continues to adjust with the restored tidal connectivity, the relative abundance of the estuarine species may increase along with additional species using the available habitat. To measure the ecological success of restoration efforts, we recommend long-term monitoring to detect these recovery patterns and rates.

We saw decreased abundance of Coastal Cutthroat Trout and Coho Salmon after restoration construction in the Ni-les'tun Unit. For both of these salmonids, double fyke hoop net trap CPUE was significantly lower and fewer fish were captured electrofishing than before restoration. The decreased capture of these species may be due to the transformation of their habitat. Gray et al. (2002) found that the response of different fish species in a restored estuarine environment may be linked to variations in salinity, food availability, and changing channel conditions. These conditions create a sequence of habitat types that provide variable estuarine and freshwater holding periods (Bottom et al. 2005b). Coho Salmon rely on consistent freshwater much of the year before moving rapidly through the estuary as they transition into saltwater (Bottom et al. 2005b). Coastal Cutthroat Trout likely moved farther upstream into perennial creeks where culvert passage was improved. The previous conditions in the Ni-les'tun Unit (i.e., slack water and limited estuarine circulation) may have created atypical tidal marsh habitat and prolonged salmonid residence time. Additionally, after restoration construction, high water levels and associated flooding prevented our ability to sample sites in the tidally influenced area. According to Miller and Sadro (2003), there may have been a greater opportunity to capture juvenile Coho Salmon at these times when they were actively or passively moving downstream from freshwater habitats. The observance of fewer Coho Salmon and Coastal Cutthroat Trout in the Ni-les'tun Unit after restoration construction may indicate the habitat is currently a transition zone rather than a holding area. However, early-life-history Coho Salmon prior to completing smoltification have been observed rearing and overwintering in estuarine habitats (Bass 2010; Hoem Neher et al. 2013). This suggests the Ni-les'tun Unit has the potential to provide juvenile Coho Salmon with appropriate habitat for prolonged residence. Although the two salmonids utilize the Ni-les'tun Unit differently after restoration construction, the Ni-les'tun Unit may improve access to quality forage at high tide and better facilitate their transition into saltwater (Miller and Simenstad 1997).

In contrast, it appears there was a system-wide increase in Chinook Salmon during the sampling period. We found a greater abundance of small juvenile Chinook Salmon in both the control area and Ni-les'tun Unit after restoration. This increase may be influenced by variable ocean conditions (i.e., temperature and movement, local conditions, upwelling) affecting juvenile salmonid survival to adulthood (Dale et al. 2016). Cold conditions in 2008 and 2009 were relatively good to neutral for juvenile Salmon survival following several years of poor conditions between 2003 and 2005 (Peterson et al. 2012). The 2008 and 2009 conditions may have resulted in improved coastal fall Chinook Salmon adult escapement and spawning documented in 2011 and 2012. In turn, improved escapement and spawning may have led to increased small juvenile Chinook Salmon in 2013 (ODFW 2013). The tidal cycles created by the restoration may have also created habitat suited to the transitory residence time for Chinook Salmon (Hering et al. 2010). In the future, it may be necessary to sample during high flows to detect episodic use of the tidal area. As the habitat evolves, juvenile Chinook Salmon may have the ability to express behaviors ranging from early migration to prolonged estuarine rearing (Healey 1980, Levy and Northcote 1982; Bottom et al. 2005a). Ultimately, it appears this restoration may provide juvenile Salmon with increased opportunities to utilize habitat that has the capacity to support various life-history strategies (Tanner et al. 2002).

We expect distribution of fish species to continue to change over time with the reestablishment of historic habitat features associated with a functioning tidal wetland (e.g., channel vegetation, increased water depth) that benefit salmonids and other native estuarine species (Williams and Zedler 1999; Brown 2003). Although we did not design this study to analyze the relationship between fish distribution and these parameters, we know distribution of salmonids, native estuarine fish, and nonindigenous species in tidal wetlands is correlated with channel width, salinity, dissolved oxygen (Williams and Zedler 1999), water depth, proximity and type of channel vegetation (Baltz et al. 1993; Peterson and Turner 1994), habitat structural composition, flow velocity, stream order, wave exposure, and turbidity (Allen 1985; Meffe and Sheldon 1988; Ruiz et al. 1993; Paller 1994; Clark et al. 1996). With the removal of the dike on the Ni-les'tun Unit, there are documented changes in some of these parameters (e.g., salinity, channel morphology; Brophy et al. 2014) and we expect others will change with the more direct, open connection to the Coquille River intertidal zone (e.g., flow velocity, wave exposure).

This study contributes to our ability to conserve and manage tidal wetlands by evaluating the short-term effects of restoration and establishing a baseline to monitor long-term trends of fish species presence, abundance, and diversity. The natural hydrology of the restoration has not reached a stable condition and our short-term monitoring reflects the initial response of fish to the restoration actions. The overall goal of this project was to improve quantity and quality of tidal wetlands and estuarine conditions for a variety of aquatic species, including native trout and other salmonids. We found more estuarine fish present and continued presence of all salmonid species of varying size-classes. The conditions created by the return of a natural tidal regime provides suitable aquatic habitat for these species. Although Sculpin and Threespine Stickleback were the most abundant species, many other species utilized the habitat at various life history stages. It is important to consider the multiple habitats these species require for positive lasting effect on the larger landscape (Morley et al. 2005). Long-term monitoring of this area to assess changes in fish assemblage, distribution, and relative abundance will provide added insight to the degree of benefit this project provides to salmonids and other native estuarine species. This information will be useful for refining adaptive management plans in the Coquille River watershed and guiding wetland restoration projects in the future.

Supplemental Material

Please note: The *Journal of Fish and Wildlife Management* is not responsible for the content or functionality of any supplemental material. Queries should be directed to the corresponding authors for the article.

Data S1. Data for fish captured in Bandon Marsh National Wildlife Refuge, Oregon, from 2007 to 2013. This file includes 16,148 records and 24 fields. Fields include sample event, strata, sample area (Ni-les'tun Unit or control area), restoration phase (pre- or post-restoration construction), sample dates and times, sample method, creek name, site code, net size (cm), water temperature (°C), conductivity (μS), and salinity (parts per thousand), soak time, electrofishing effort and settings, species, fork length (mm), weight (g), and species count. Found at DOI: http://dx.doi.org/10.3996/112016-JFWM-083.S1 (1,801 KB xlsx)

Reference S1. Brophy LS, van de Wetering S. 2012b. Ni-les'tun tidal wetland restoration effectiveness monitoring: progress report, January 2013. Report of Green Point Consulting to the Institute for Applied Ecology, and the Confederated Tribes of Siletz Indians, Corvallis, Oregon.

Found at DOI: http://dx.doi.org/10.3996/112016-JFWM-083.S2 (3,260 KB PDF).

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Found at DOI: http://dx.doi.org/10.3996/112016-JFWM-083.S3; also available at http://www.westcoast.fisheries.noaa.gov/publications/reference_documents/esa_refs/section4d/electro2000.pdf (74 KB PDF).

Reference S3. [ODFW] Oregon Department of Fish and Wildlife. 2013. Coastal and Columbia River salmon and steelhead 2012–2013.

Found at DOI: http://dx.doi.org/10.3996/112016-JFWM-083.S4 ((1,449 KB PDF).); also available at http://www.dfw.state.or.us/agency/budget/docs/13-15_ways_and_means/n6-2013_STATE_OF_SALMON1.pdf (1,449 KB PDF).

Reference S4. Dahl TE. 2011. Status and trends of wetlands in the conterminous United States 2004 to 2009.

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Found at DOI: http://dx.doi.org/10.3996/112016-JFWM-083.S6; also available at https://www.fws.gov/uploadedFiles/1_BandonMarshNWR.FinalCCP%20web.pdf (25, 193 KB PDF).

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Found at DOI: http://dx.doi.org/10.3996/112016-JFWM-083.S8 (2,824 KB PDF).

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Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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